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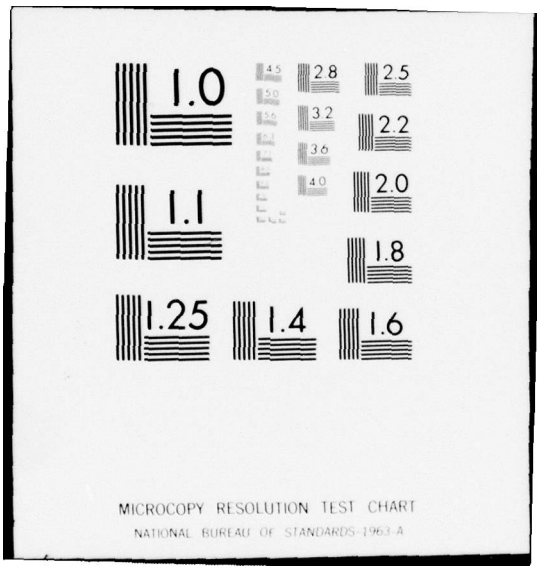
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Book 13
Soil Data

Seafarer Site Survey
Upper Michigan Region

for
U.S. Navy
Naval Electronic Systems Command
Washington, D.C.

by
EDAW inc.
under contract to
GTE Sylvania
Communication Systems Division

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Thick glacial deposits mantle the bedrock throughout most of the study area. Near surface soils have formed as a result of in place decomposition of glacially deposited parent material and ranges in thickness from a few inches to a few feet. However, soil and glacial deposits are entirely absent on many knobs and ledges where hard rock crops out at the surface.

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20. The predominant soil types in the area are sandy and silty loams, and loamy sands. A Soil Data Map which has been compiled from existing sources provides information as to the approximate thickness and type of soil present in a general area.

BOOK 13

SOILS DATA
of the
UPPER MICHIGAN REGION
PROJECT SEAFARER

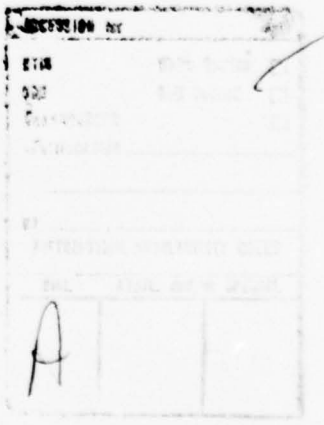
for
U. S. Navy. Naval Electronic Systems Command

by
EDAW, Inc., 50 Green Street, San Francisco 94111

Under Contract to
GTE Sylvania, Communication Systems Division

April, 1976

CONTENTS



SUMMARY

Appreciable thicknesses of glacial deposits (a few to more than 300') mantle the bedrock throughout most of the Study Area, and the near-surface soils have formed as a result of in-place decomposition of this transported parent material. The thickness of the soil horizons is only a few inches to a few feet, and in most areas they grade downward into glacial deposits of till, moraine, outwash, or lacustrine deposits. Soil and glacial deposits are entirely absent on many knobs and ledges where hard rock crops out at the surface. Alluvial soil deposits (water-transported deposits not associated with glacial-related processes) exist locally within narrow, rocky streambed areas, and are generally only a few feet thick.

There is a direct relationship between the type of soil present and the underlying parent material. Soils overlying outwash deposits are predominantly sand or sandy loam at the surface, grading downward to sand and gravel. Soils which have formed over clay-rich glacial till and lacustrine deposits consist of silty loam to loamy clay, and are generally thicker than the soils overlying outwash. Thick, mucky peat soils overlie organic deposits. The predominant soil types present in the Study Area are sandy and silty loams, and loamy sands.

The Soil Data Map is a compilation of data from existing sources that are unchecked in the field (see Validity). The relationship to the Surficial and Bedrock Geologic Data Maps prepared during this study (also described under Validity) must be kept in mind during its use. The areal distribution of soil associations (groupings of soils with similar characteristics and thicknesses) is shown essentially as mapped by the Soil Conservation Service of the U. S. Department of Agriculture, with minor adjustments by ESA to fit the topographic base and allow matching of similar units across county lines. Although the information presented is very generalized, the Soil Data Map provides a useful check on the approximate thickness and type of soil present in a general area (but not necessarily at a precise location). Similarly, the descriptions of soil types and the accompanying tables provide generalized information useful in evaluating the character of near-surface materials present.

EVOLUTION

Processes and Time Leading to the Existing Condition

Soils form from complex physiochemical processes acting on available near-surface earth materials. Soil forming processes generally form subhorizontal layers or horizons with certain textural, structural, and compositional characteristics that are the result of local environmental conditions. In the Study Area, most soils have three main horizons designated as A, B, and C. The A horizon is immediately below the ground surface and is the zone of maximum biologic activity. It is commonly called the zone of aluviation because it is subject to leaching by percolating water. Materials removed include dissolved iron and aluminum silicates, and physically transported clay minerals. The B horizon is called the zone of illuviation because the leached material from the A horizon is deposited or reprecipitated. The C horizon consists of partially weathered parent material that has not as yet undergone soil-forming processes. Calcium carbonate that has been leached from the upper material is often found in the upper portion of this horizon. A soil series, or kind of soil, is defined largely on the thickness and character of these horizons.

Important factors affecting the soil series that develops in a given area include the character of the parent material, local topography and drainage, vegetation, climate, and length of time the soil-forming processes have been active. In the Study Area, the climate and length of time for soil development can be considered constant over the entire area. Of the remaining three factors, the character of the parent material is probably most important in determining the type of soil that develops. Surficial soils formed on outwash deposits are predominantly sand or sandy loam, and those developing on clay-rich glacial till and lacustrine deposits are predominantly silty loam to loamy clay.

Topography and local drainage are also important in soil formation. In topographically high, well drained areas, the soil horizons are generally distinct and well differentiated in properties such as color, texture, and structure. In poorly drained areas, the individual horizons are much less distinct. In low areas, where the water table is at or slightly above the ground surface, densely vegetated swamps develop. As plant debris accumulates and partially decays, organic and peaty soils develop.

Thus, in summary, the gross characteristics of the soils in the Study Area are related to the underlying parent material, particularly in mineralogy and particle size. Additional variations in soil type occur because of different topographic positions and drainage, and vegetation. Some differences within mapped units also occur because of lack of uniformity in the parent material. Glacial deposits that underlie most of the Study Area characteristically exhibit both horizontal and lateral changes in composition and texture that may be abrupt or gradational. This fact, coupled with topographic and vegetational controls, results in a very complex array and distribution of soil characteristics. Consequently, the existing soil maps covering the Study Area are approximations that do not reflect many local details.

Anticipated Future Conditions

A steady state condition in the soil prevails within areas where man has not modified the land surface. The material that is removed from the surface by the relatively slow erosion is counterbalanced by deeper chemical weathering of the underlying earth materials so that a constant soil thickness persists. Geologically speaking, the Michigan soils are still immature compared to soils present in some other parts of the world. They are still actively forming more definitive soil horizons. However, in the context of time spans of decades, the soils should be considered as existing in a steady state condition.

Soils within the Study Area have a relatively low sensitivity to disturbance (in comparison, for example, to tropical environments), and do not appear to be an endangered resource.

DISTINCTIVE UNITS AND CHARACTERISTICS

The soil units shown on the Soil Data Map are soil associations, as mapped by the U. S. Department of Agriculture, Soil Conservation Service. A soil association is a grouping of soil series, of kinds of soils, with similar characteristics that are often formed on the same parent material. The soils in an association tend to occur in a certain repetitive pattern on the landscape. For example, on a uniform parent material, a specific soil series may develop in the upland areas, another on similar hill slopes, and another in the lowlands. The proportion of each soil series within the association will vary from place to place, depending largely on the local topography and drainage.

The map symbols used to represent each soil association are the first two letters of the soil series comprising the greatest percentage of the association. If the same soil series made up the greatest percentage of two or more soil associations, the first two letters of the second most prominent soil series was added to the map symbol.

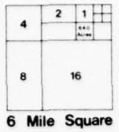
The soil associations on the Soil Data Map are described in Table 1. This table lists the soil series represented by each map symbol and the percent of the principal soil series in the association (in parentheses after the series).

Table 2 gives a brief description of each of the soil series present in the Study Area.

The soil associations present in the Study Area have been grouped into five units shown by different colors on the Soil Data Map on the basis of soil texture. For example, all sandy loams are represented by the same color. Table 3 lists the soil associations which are represented by each unit.

Appendices A, B, C, and D present information on general soil series data, estimated engineering properties, soil suitability and features affecting use, and degree and kind of limitation for selected use.

Seafarer Site Survey
Upper Michigan Region



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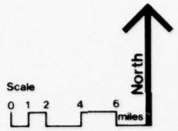
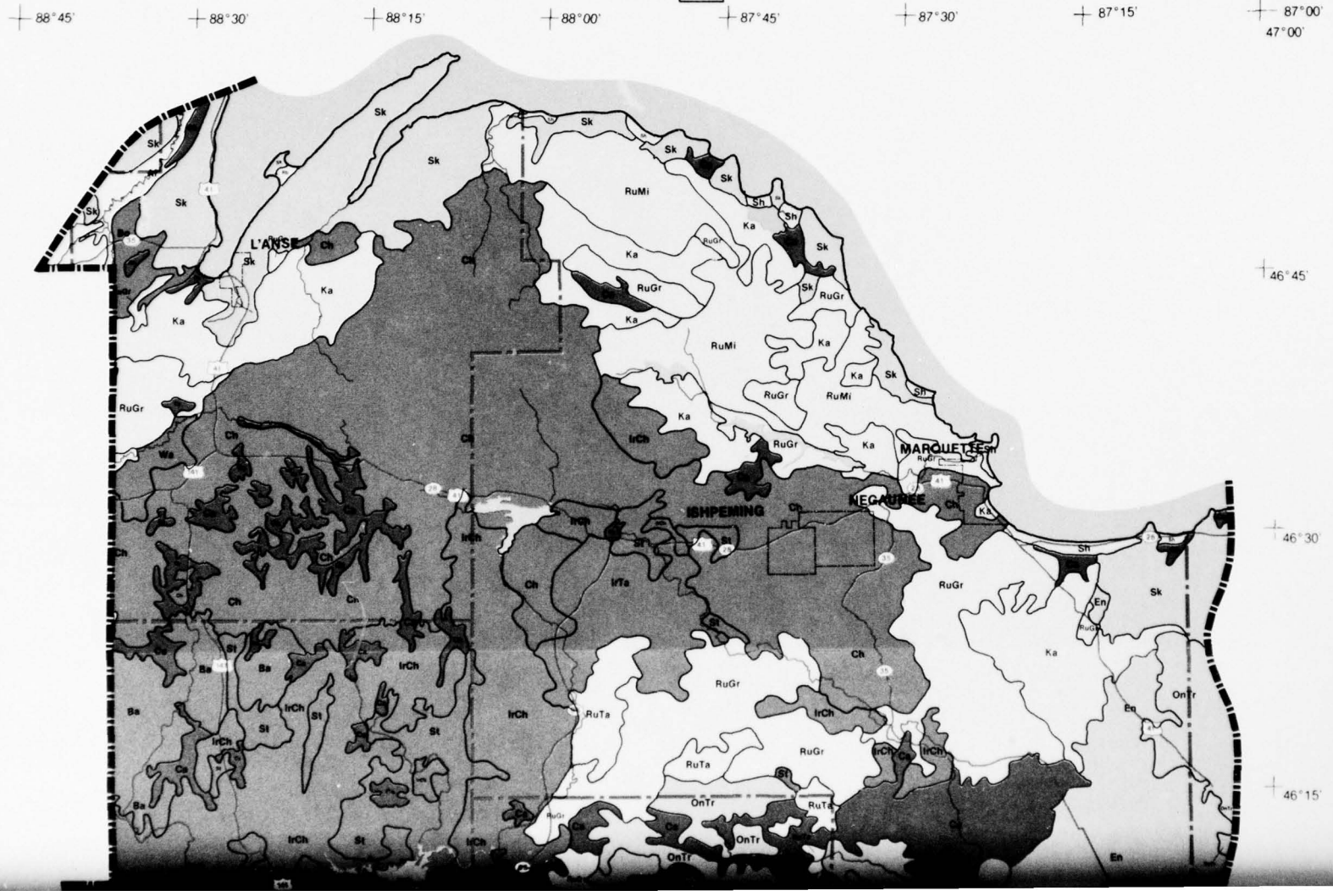


SOILS

- Wa — Soil Type (See Text)
- Mucky Peat
- Alluvium
- Silt Loam
- Sand
- Sandy Loam



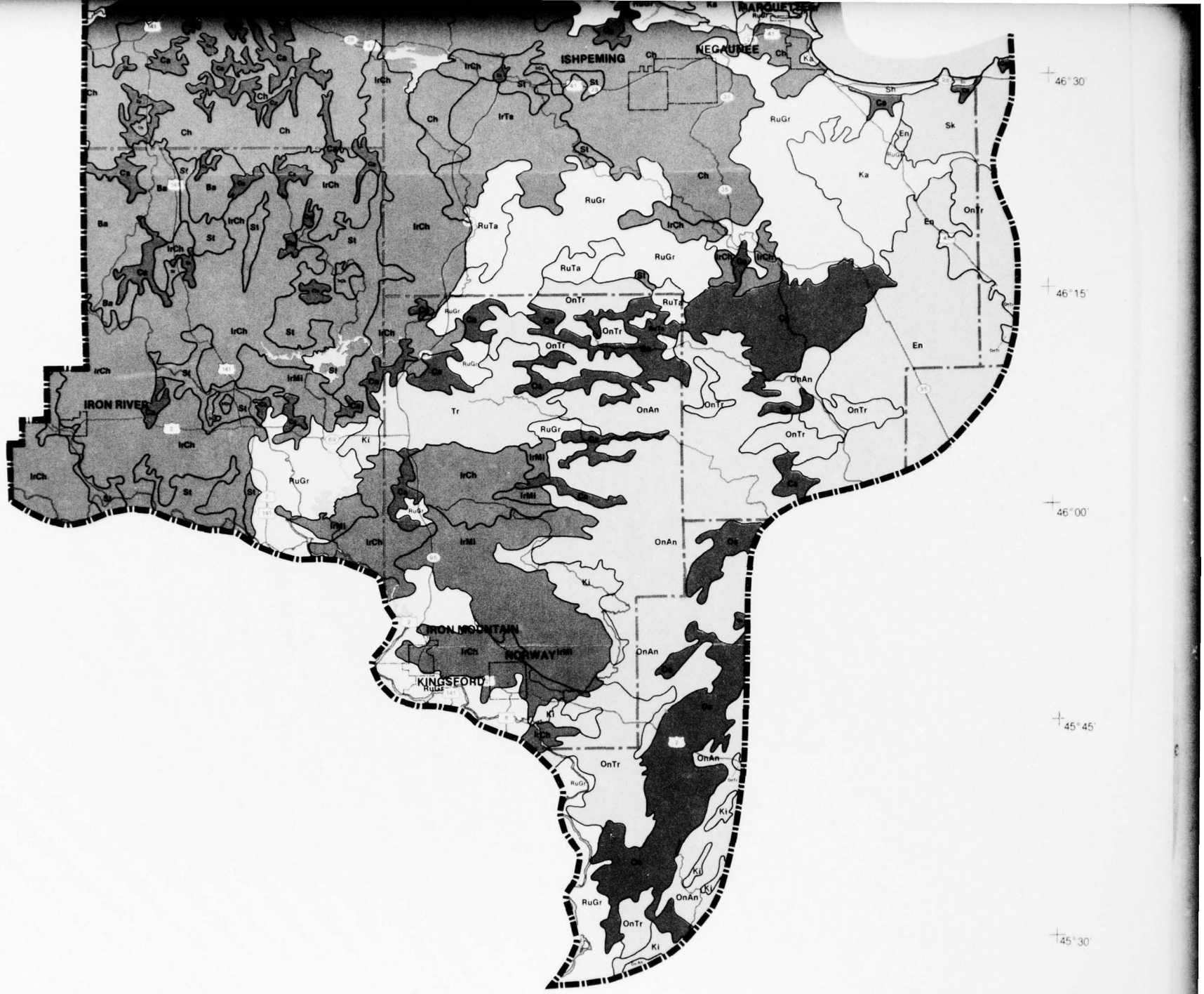

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Table 1. SOIL DATA MAP UNITS
(Soil Associations)

Map Symbol	Soil Series in the Association (50) = % of Series in Association
Al	Alluvial land (80), Organic soil (10)
Ba	Baraga (30), Champion (30), Amasa (10)
Bo	Bohemian (40), Rousseau (30), Ontonagon (20)
Ca	Carbondale (30), Greenwood (12.5), Rifle (7), Tawas (4), Pleine (3), Kiva (3), Tacoosh (3) Mancelona (2.5)
Ch	Champion (30), Michigamme (20), Baraga (15), Rockland (7), Iron River (2)
En	Ensley (30), Charlevois (25), Tacoosh (5), Cathro (2), Trenary (1)
IrCh	Iron River (60), Champion (20), Goodmar (10) Amasa (2)
IrMi	Iron River (35), Michigamme (20), Rockland (15)
IrTa	Iron River (35), Tacoosh (20), Michigamme (20)
Ka	Kalkaska (40), Munising (20), Bohemian (8) Gogebic (5)
Ki	Kiva (25), Newaygo (20), Mancelona (10), Tawas (3), Trenary (2), Karlin (1)
OnAn	Onaway (40), Angelica (20), Trenary (5), Carbondale (4), Cathro (1)
OnTr	Onaway (40), Trenary (25), Longrie (10)
Os	Organic Soils (45), Longrie (25), Onaway (20)
Rb	Rough broken land (90)
RuGr	Rubicon (45), Grayling (7), Kalkaska (6) Pence (5), Keweenaw (3), Roscommon (2), Rousseau (1)

Table 1. SOIL DATA MAP UNITS
(Soil Associations) continued

Map Symbol	Soil Series in the Association (50) = % of Series in Association
RuMi	Rubicon (40), Michigamme (12), Rockland (10)
RuTa	Rubicon (35), Tawas (25), Roscommon (12.5), Carbondale (8)
Sh	Shelldrake (35), Roscommon (20), Tawas (15) Angelica (3)
Sk	Skanee (40), Munising (35), Keweenaw (10), Onota (5)
St	Stambaugh (25), Pence (10), Amasa (10), Organic (5)
Tr	Trenary (35), Onaway (30), Carbondale (15)
Wa	Watton (90)

Table 2. SOIL SERIES DESCRIPTIONS

Soil Series	Description*
Amasa	very dark gray to reddish brown, very fine sandy loam to loamy sand; weak to strong, medium granular structure; friable; strongly acid.
Angelica	black to grayish red-brown loam to sandy loam to sandy clay loam; weak, fine to medium subangular blocky structure; common fine to medium distinct dark gray to yellowish red mottles; friable; neutral; sticky in lower B and C horizons.
Baraga	pinkish gray to dark reddish brown silt loam; weak, very fine subangular blocky structure; very friable, common fine roots; strongly acid.
Bohemian	pinkish gray to dark brown to brown silt loam to fine sandy loam; weak to moderate, fine to medium subangular blocky structure; friable; many roots throughout; strongly to medium acid.
Carbondale	very dark gray to brown highly decomposed organic material, primarily from herbaceous plants; 10 to 70 percent fiber; weak, medium granular structure; slightly acid.
Cathro	black, highly decomposed organic material, primarily from herbaceous plants, 35 to 40 percent fiber; weak, fine to medium granular structure; medium acid to neutral.
Champion	dark reddish gray to yellowish red silt loam; weak to moderate, medium granular to subangular blocky structure; friable; strongly to medium acid.
Charlevoix	grayish to reddish brown sandy loam to light sandy clay loam; moderate, fine granular to weak to moderate subangular block structure; friable to firm; slight acid to neutral.

*See Soils of Michigan by Whiteside, Schneider, and Cook, 1968, for definitions of the terms used in these descriptions.

Table 2 (continued)

Soil Series	Description
Ensley	grayish brown to brown sandy loam; moderate fine to medium granular to weak, medium subangular blocky structure; common medium distinct yellowish brown to light brownish gray mottles; friable to firm; neutral to mildly alkaline and calcareous.
Gogebic	reddish brown to yellowish red fine sandy loam; moderate, medium granular to weak, fine to medium subangular blocky structure; friable to firm; strongly to medium acid.
Goodman	dark brown to brown silt loam to sandy loam; argillic horizon; weak, very fine crumb to weak, very thin platy structure; very friable, medium to strongly acid.
Grayling	black to brown sand; weak, coarse crumb to single grain structure; very friable to loose; very strongly to medium acid.
Greenwood	dark reddish brown to dark brown hemic (blood color) material 40 to 60% herbaceous fibers; weak, thin platy structure; extremely acid.
Iron River	brown to reddish gray-brown silt loam to light sandy loam; very fine subangular blocky to weak, thin platy structure; friable to very firm; plentiful to few fine roots; strongly to medium acid.
Kalkaska	dark brown to light yellowish brown sand; weak, medium to coarse granular structure to structureless; single grain matrix; very friable to loose; strongly to slightly acid.
Karlin	pinkish gray to yellowish brown sandy loam to sand; weak, fine to coarse granular structure to single grain; very friable to loose; numerous roots; medium to strongly acid.
Keweenaw	reddish gray to reddish brown loamy sand to sand; weak, fine to medium crumb structure to single grain; very friable to loose; strongly acid.
Kiva	very dark brown to reddish brown sandy loam; weak, medium granular to weak, fine subangular blocky structure; very friable to loose; many roots; slightly acid to mildly alkaline to calcareous.

Table 2 (continued)

Soil Series	Description
Longrie	dark brown to reddish brown loam; moderate medium granular to weak, fine to medium subangular blocky structure; 3% gravel fragments; friable; neutral.
Mancelona	dark grayish brown to yellowish brown loamy sand to gravelly sandy loam; weak, fine to coarse granular to weak, fine to medium subangular structure; friable; numerous roots in A and upper B horizons; slightly acid.
Michigamme	pinkish gray to dark reddish brown fine sandy loam; weak, fine to medium subangular blocky structure; friable; many roots in A and upper B horizons; strongly acid.
Munising	pinkish gray to reddish brown sandy loam to loamy sand; weak, fine to coarse granular to weak, coarse subangular blocky structure to massive; friable to firm to vesicular; slightly hard to very hard and compact; strongly acid.
Newaygo	dark grayish brown to yellowish brown sandy loam to gravelly light clay loam; weak, medium granular to moderate medium to coarse subangular structure; friable to firm; numerous roots in A and upper B horizons; slightly acid to neutral.
Onaway	brown to dark to light reddish brown fine sandy loam to clay loam; moderate medium granular to weak coarse subangular blocky structure; friable to very firm; many fine roots in A and B horizons; mildly alkaline.
Onota	grayish brown to reddish brown sandy loam; weak, medium subangular blocky structure; friable; medium to strongly acid.
Ontonagon	dark reddish brown and gray silty clay; dry; very weak, medium subangular blocky structure; A_2 heavy clay, extremely firm, heavy plastic red lacustrine clay with lenses of silt clay loam; calcareous; medium acid.
Pence	reddish gray-brown to brown sandy loam to sand and gravel; weak, fine to medium subangular blocky structure to single grain to massive; friable to somewhat coherent; medium acid.

Table 2 (continued)

Soil Series	Description
Pleine	black to dark reddish brown-gray loam; moderate, fine granular to weak, medium subangular blocky structure; friable; strongly to medium acid.
Rifle	black to dark reddish brown decomposed organic material, 65 to 90 percent fiber, primarily herbaceous; few woody fragments; massive to weak thick platy structure; neutral.
Roscommon	black to grayish brown loamy sand to sand; coarse to medium distinct yellowish brown mottles, many roots; structureless; single grain; very friable to loose; neutral to mildly alkaline.
Rousseau	pinkish gray to dark reddish brown to yellowish red fine sand; weak, medium crumb to weak, fine subangular blocky structure to single grain; very friable to loose; strongly to medium acid.
Rubicon	light brownish gray to yellowish brown sand; weak, medium granular to weak, coarse subangular blocky structure; very friable to loose; common roots in A and upper B horizons; strongly acid to slightly acid.
Shelldrake	light brownish gray to pale brown to white sand; single grain; loose, strongly acid.
Skanee	pinkish gray to reddish brown sandy loam; contains distinct yellowish red mottles; weak, medium granular to weak, medium subangular blocky to weak, thick platy structures; friable to very firm; very strongly acid.
Stambaugh	very dark brown to reddish brown silt loam to coarse to heavy silt loam; weak, medium subangular blocky to weak, thin platy structure; friably to loose; strongly acid.
Tacoosh	black to very dark brown decomposed herbaceous materials to sandy loam; 20 to 60 percent fiber; fine to medium granular structure to massive; medium acid to mildly alkaline.

Table 2. (continued)

Soil Series	Description
Tawas	black highly decomposed organic layers to fine sand; 20 to 50 percent herbaceous to woody fibers; weak, medium granular structure to massive; neutral.
Trenary	brown to reddish brown fine sandy loam to sandy clay loam; weak to moderate, fine to medium subangular blocky structure; friable; strongly acid.
Watton	reddish brown silt loam to silty clay loam; weak to moderate medium to coarse angular blocky structure; common discontinuous micropores; common fine faint reddish brown and yellowish red mottles; common very fine roots; friable to firm; medium acid to moderately alkaline, slight to strong effervescence in lower B and C horizons.
Witbeck	black to brown stony loam to gravelly sandy loam; common medium distinct mottles of gray and brown; weak, medium subangular blocky structure; very friable; medium to slight acid.

Table 3. SOIL GROUPS

Soil Associations in Group	Prominant Texture
Ka, RuGr, RuMi, RuTa, Sh	Sand
En, Ki, OnAn, OnTr, Sk, Tr	Sandy loam
Ba, Bo, Ch, IrCh, IrMi, St, Wa, IrTa	Silt loam
Ca, Os	Mucky peat
Al, Rb	Alluvium

RELATIONSHIP TO OTHER DATA

Soils within the Study Area are directly related to the glacial deposits which they overlie, as discussed under Relationship to Other Data in the Surficial Geologic Data narrative. Soils overlying outwash deposits are predominantly sandy at the surface, grading downward to sand and gravel. Soils which have formed over clay-rich glacial till and lacustrine deposits consist of silty loam to loamy clay and are generally thicker than those soils overlying outwash. Soils overlying organic deposits tend to be thick, mucky peat soils.

Little or no soil has developed in areas where bedrock is exposed, primarily due to slow weathering and breakup of the rocks. The presence of glacial striations, or "scratches", on the surface of some of the in-place crystalline rocks indicates that very little rock has been removed by weathering during the last 10,000 years.

Climate has played a major role in determing the types of soils found in the Study Area. The humid climate of Michigan has resulted in the removal of the easily soluble constituents from the upper layers of most of the soils. Some of these constituents have been washed out of the surface horizons and deposited in the sub-soil. This has resulted in the formation of podzol soils (soils with moderately well developed A, B and C horizons) encountered throughout Michigan. The effects of topographic position and soil biota on soil formation is discussed under Evolution.

The types of soil present in the Study Area have an obvious effect on vegetation and consequent land use. Bogs and other depressions in till plains, for example, are characterized by mucky peat soils. Due to the high acidity of these soils, bogs and depressions are of little value as cropland or pasture because few types of vegetation are suited to these areas. Because many of the soils are thin and rocky or sandy, much of the land is not suitable for cultivation. Sandy and silty loam soils which have been cleared are suitable for pasture land, but forest or woodlands clearly dominate the landscape.

For the same reason that the types of soil present affect vegetation and land use, land value is affected, and the price of good cropland where soils are thicker is greater than rangeland where the soils are thin and rocky.

VALIDITY

Three separate Geologic/Soils Data Maps and associated reports have been prepared during this study, and an understanding of the basis for their preparation is essential for proper use.

Bedrock Geologic Data Map

This map represents an unchecked field compilation of pertinent existing bedrock geologic mapping available for the Study Area. As in the case with most available geologic mapping anywhere, surficial deposits are largely ignored, and the map shows the types of rock present at depth throughout the area. Little information is presented that pertains to the condition of the rock at or near the surface, or to the presence or absence of soil deposits in a given area.

Although complete coverage of the Study Area was available, various scales of mapping had to be utilized in compiling this map, ranging from 1:24,000 to 1:500,000. As a result, the information presented is more accurate in some portions of the Study Area than it is in others, although an attempt was made to attain a uniform level of detail. The geology of the rocks of Precambrian age (which encompasses the majority of the Study Area) is from Willard A. Bodwell's 1972 map, "Precambrian Geology of Upper Peninsula, Michigan". Geologic data for Paleozoic rock formations were obtained from maps varying in detail and scale. At present, little detailed mapping of the Paleozoic bedrock in this area has been done. Limited photogeologic mapping was also done where coverage was available.

This map provides a basis for determination of the rock type present within any general section of the Study Area. Rock quality is not shown. The map represents a compilation (without field checking) of all pertinent available information, and should be considered the most complete available map of geologic formations present throughout the Study Area.

Surficial Geologic Data Map

This map represents an unchecked field compilation of pertinent existing surficial geologic mapping, and the accompanying narrative presents information pertaining to surficial soil and geologic conditions throughout the Study Area as they apply to engineering projects.

As was the case with the Bedrock Geologic Data Map, complete surficial geologic coverage of the Study Area was available at various scales, ranging from 1:11,904 to 1:500,000. Consequently, the level of detail varies from some portions of the map to others. Aerial photographs were used in areas of inadequate coverage, but did not provide significant amounts of additional information.

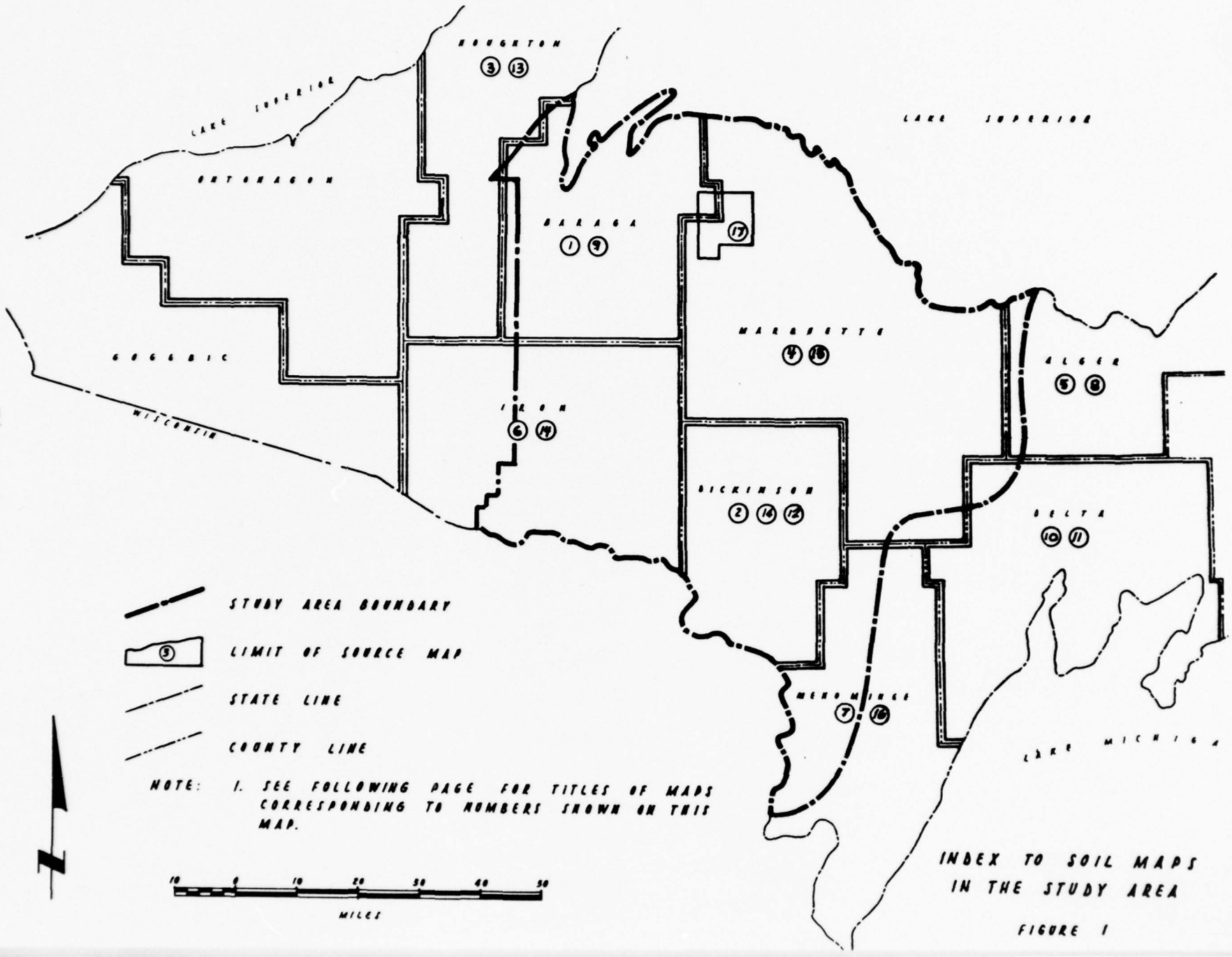
This map provides a basis for evaluating the physical properties of near-surface materials present throughout the area. In particular, the distribution of hard rock outcrops and near-surface rock is shown, and where soil, outwash, till, swamp and recent alluvium and morainal desposits exist at the surface, an estimate of thickness has been made. Use of this map should provide an indication of the relative plowability or rippability of various portions of the Study Area. Where rock outcrops have been mapped, the type of rock can be determined by overlaying this map on the Bedrock Geologic Data Map. Similarly, where thin glacial deposits are shown on the Surficial Geologic Data Map, the general type of bedrock that will be encountered in deep excavations can be determined by the same technique.

Soil Data Map

This map is a field unchecked compilation of existing soil mapping by the Soil Conservation Service of the U. S. Department of Agriculture in the Study Area. This mapping was done primarily for agricultural purposes, but provides useful information on type of soil and soil depth, with supplementary information pertaining to engineering properties (presented in tables in the Appendix). An index to existing soil maps in the Study Area is presented as Figure 1.

Complete coverage of the Study Area was available at a scale of 1:190,000 (1" = 3 miles). This coverage represents a relatively consistent level of detail in the field work leading to the development of each county soils map. The maps show generalized soil information which is useful for general planning. The data presented on this map regarding the type of soil, and in particular, in the accompanying table with regard to soil depth, should be taken only as a general guide to average soil conditions in the area, and not as detailed information at a specific location.

This map should be used jointly with the Surficial Geologic Data Map to provide a basis for assessment of surficial materials throughout the Study Area. The Surficial Geologic Data Map is far more detailed, and provides relatively accurate information on the location of rock outcrops. The Soil Data Map should be used as a check on the Surficial Geologic Data Map regarding soil depth.



INDEX TO SOIL MAPS IN THE STUDY AREA

FIGURE 1

SOIL MAPS IN THE STUDY AREA

Michigan State College, Agricultural Experiment Station

1. Baraga County, Natural Land Type Map, field work 1941, Michigan State College Agricultural Experiment Station, Conservation Institute and Soil Science Section, I. F. Schneider. Scale: 1" = 1 mile. One map, blue line.

2. Dickinson County, Natural Land Type Map, field work 1938, Michigan State College Agricultural Experiment Station, Conservation Institute and Soil Science Section, I. F. Schneider. One map, blue line.

3. Houghton County Land Type Map, field work 1942-1943, Michigan State College, Agricultural Experiment Station, Conservation Institute and Soil Science Section. Preliminary land type legend revised by I. F. Schneider, October 1949. Two maps, blue line.

4. Marquette County, Natural Land Type Maps, field work 1939-1940, Michigan State College Agricultural Experiment Station, Conservation Institute and Soil Science Section, Preliminary land type legend revised by I. F. Schneider. Three maps, blue line.

USDA, Bureau of Chemistry and Soils

5. Alger County, Land Economic Survey, field work 1928, published 1934 (USDA, Bureau of Chemistry and Soils). Scale: 1" = 1 mile.

6. Soil Survey of Iron County, No. 36, Series 1930, issued March 1937, USDA, Bureau of Chemistry and Soils. Scale: 1" = 1 mile. Colored map.

7. Soil Survey of Menominee County, No. 31, Series 1925, USDA, Bureau of Chemistry and Soils. Scale: 1" = 1 mile. Colored map.

USDA, Soils Conservation Service

8. Alger County, Soil Conservation Service, General Soils Map, 1972. Scale: 1:190,000.

9. Baraga County, Soil Conservation Service, General Soils Map, 1972. Two sheets. Scale: 1:190,000.

10. Delta County, Detailed Soil Survey, Soil Conservation Service, completed 1967, scheduled publication 1975.

11. Delta County, Soil Conservation Service, General Soils Map, 1972. Two sheets. Scale: 1:190,000.

12. Dickinson County, Soil Conservation Service, General Soils Map, 1972. One sheet. Scale: 1:190,000.

13. Houghton County, Soil Conservation Service, General Soils Map, 1972. Two sheets. Scale: 1:190,000.

14. Iron County, Soil Conservation Service, General Soils Map, 1972. Two sheets. Scale: 1:190,000.

15. Marquette County, Soil Conservation Service, General Soils Map, 1972. Three sheets. Scale: 1:190,000.

16. Menominee County, Soil Conservation Service, General Soils Map, 1972. Two sheets. Scale: 1:190,000.

17. Ottawa National Forest, McCormick Tract, USDA Forest Service, 1969. Scale: 1" = 1/2 mile.

BIBLIOGRAPHY

U. S. Department of Agriculture, Soil Conservation Service. Soil Series Descriptions, and Soil Interpretation Sheets for the following Soil Series:

Amasa	Goodman	Munising	Rubicon
Angelica	Grayling	Newaygo	Shelldrake
Baraga	Greenwood	Onaway	Skanee
Bohemian	Iron River	Onota	Stambaugh
Carbondale	Kalkaska	Ontonagon	Tacoosh
Cathro	Karlin	Pence	Tawas
Champion	Keweenaw	Pleine	Trenary
Charlevoix	Kiva	Rifle	Witbeck
Ensley	Longrie	Roscommon	
Gogebic	Mancelona	Rousseau	
	Michigamme		

U.S. Department of Agriculture, Soil Conservation Service, 1972. General Soil Maps of the following counties in Michigan. Scale: 1" = 4 miles. Alger, Baraga, Delta Dickinson, Iron, Marquette, Menominee.

U.S. Department of Agriculture, Soil Conservation Service, 1973. L. W. Berndt, Soil Scientist, personal communication.

Whiteside, E. P., Schneider, I. F., Cook, R. L., 1968. Soils of Michigan. Michigan State University, Extension Bulletin E-630.

APPENDIX A

GENERAL SOIL DATA

GENERAL SOILS DATA

Soil Series	Soil Description	Environment	Parent Material	Dominant Slope Range (percent)	Soil Thickness (in inches)
Amasa	fine sandy loam	Steep outwash plains, old river terraces, and on kames and moraines.	Medium to coarse sand and gravel glacial till.	1-10	18-30
Angelica	loam	Nearly level to depressional areas on till plains.	Loamy till.	0-2	15-30
Baraga		Till plains and moraines.	Loamy till.	2-15	25-45
Bohemian	silt loam	Lake and outwash plains.	Silty to fine sandy outwash.	0-6	30-50
Carbondale	muck	Bogs in depressions of till plains.	Organic deposits	depressions	51
Cathro	mucky peat	Small depressions mainly within till plains, moraines, lake plains and outwash plains.	Grayish brown sandy loam.	2	16-50
Champion	silt loam	Till plains and moraines.	Fine sandy loam to coarse silt loam overlying gravelly loamy sand.	2-15	20-30
Charlevoix	sandy loam	Moraines, drumlins, and till plains.	Sandy loam glacial till.	0-6	20-40
Ensley	sandy loam	Nearly level parts or depressions on till plains and moraines.	Calcareous sandy loamy glacial till.	0-2	18-40
Gogebic	fine sandy loam	Till plains and moraines on slopes.	Sandy loam glacial till.	0-40	40-50

Soil Series	Soil Description	Environment	Parent Material	Dominant Slope Range (percent)	Soil Thickness (in inches)
Goodman	silt loam	Gently sloping to sloping till plains.	Sandy loam glacial till.	2-5	36-50
Grayling	sand	Outwash and lake plains.	Sandy till.	0-8	15-30
Greenwood	mucky peat	Bogs in depressions in till plains or moraines.	Herbaceous (acidic) organic deposits.	depressions	51
Iron River	silt loam	Nearly level to steep areas on till plains.	Sandy loam till.	2-15	30-50
Kalkaska	sand	Outwash and till plains, valley trains, moraines and old beach ridges.	Glacial till	0-40	30-48
Karlin	sandy loam	Outwash and till plains, valley trains and moraines.	Sandy loam or loamy fine sand over acid sand.	0-12	22-40
Keweenaw	loamy sand	Till plains and water-worked moraines.	Glacial till	2-15	36-50
Kiva	sandy loam	Outwash plains, lake plains, terraces, kames and moraines.	Gravel and coarse sand outwash.	0-45	18-24
Longrie	loam	Glacial lake benches and terraces.	Limestone bedrock	0-6	22-42
Mancelona	loamy sand	Outwash and lake plains, stream terraces, deltas and beach ridges.	Calcareous coarse sand and gravel.	0-12	26-38
Michigamme	fine sandy loam	Rocky knolls, frequent outcrops.	Granite crystalline bedrock.	nearly level to steep	20-40

Soil Series	Soil Description	Environment	Parent Material	Dominant Slope Range (percent)	Soil Thickness (in inches)
Munising	loamy sand	Gently sloping to steep areas on till plains.	Sandy loam till.	2-12	34-80
Newaygo	sandy loam	Outwash plains, terraces and valley trains.	Stratified sand and gravel.	0-18	24-40
Onaway	sandy loam	Level to steep slopes on till plains and moraines.	Silt loam glacial till.	2-8	18-30
Onota	sandy loam	Sandstone bedrock benches.	Sandstone bedrock.	0-12	20-40
Ontonagon	silty clay	Lake plains.	Silty clay loam to calc. clay.	2-30	10-32
Pence	sandy loam	Nearly level to sloping or pitted glacial outwash plains, stream terraces and morainic areas.	Sandy-gravelly outwash.	0-10	12-24
Pleine	loam	Level to nearly level, and depressional areas on till plains.	Sandy loam till	0-2	18-30
Rifle	mucky peat	Bogs or small potholes within till, outwash and lake plains.	Organic deposits	2	51
Roscommon	loamy sand	Nearly level parts and depressions of outwash and lake plains and in glacial drainageways.	Sandy outwash and till	0-2	20
Rousseau	fine sand	Old lake border dunes, lake plains, outwash plains.	Fine sandy outwash.	Undulating to steep	20-32

Soil Series	Soil Description	Environment	Parent Material	Dominant Slope Range (percent)	Soil Thickness (in inches)
Rubicon	sand	Till, outwash and lake plains and moraines.	Medium to coarse grained sandy till.	0-40	26-50
Shelldrake	sand	Low sandy beach ridges.	Sand low in weatherable minerals.	0-12	16-28
Skanee	sandy loam	Slightly depressional areas and drainageways on till plains.	Sandy loam	0-10	12-20
Stambaugh	silt loam	Nearly level to undulating outwash plains and stream terraces.	Sand and gravel outwash.	1-10	24-40
Tacoosh	muck	Depressional areas within till plains, moraines, lake plain and outwash plains.	Herbaceous organic deposits.	2	16-50
Tawas	mucky peat	Bogs within outwash plains, lake plains, till plains and moraines.	Woody material and sandy mineral soil.	2	20-42
Trenary	fine sandy loam	Undulating to rolling areas on till plains and moraines.	Glacial till.	2-12	30-48
Watton	silt loam	Till plains and low moraines.	Glacial till	2-12	24-60
Witbeck	stony loam	Nearly level or depressional areas on till plains.	Sandy loam or gravelly sandy loam outwash.	2	18-24

Loam is defined as a rich, permeable soil composed of a friable mixture of relatively equal and moderate portions of clay, silt and sand particles and usually containing organic matter (humus) with a minor amount of gravelly material, specifically a soil consisting of 7-27% clay, 28-50% silt, 23-52% sand.

APPENDIX B

ESTIMATED SOIL ENGINEERING PROPERTIES

ENGINEERING INTERPRETATIONS

Appendix B presents a listing of engineering properties for each of the soil series present in the Study Area. These physical and chemical properties have been measured by the USDA Soil Conservation Service. Engineering properties are given for each horizon present within various soil series, along with the thickness of the horizon in inches, and the classification of the soil in the horizon based on two common systems. Other soil types of the same series, usually differing only in texture of the surface layer, can be interpreted similarly. For example, Pleine loam differs from Pleine sandy loam mainly in surface texture. As a result, interpretations of engineering properties of the two are basically the same, differing mainly in their suitability as topsoil. Although the soils bearing the same name are similar between counties and states, the physical and chemical properties of these soils may vary somewhat from one county to another and one state to another, and this should be kept in mind when using the data.

Major Soil Horizons. The depth intervals shown are the depths of the A, B, and C soil horizons within the individual soil series. These horizons refer principally to the degree of weathering in the layers present in the soil profiles. The uppermost zone, the zone of most intense leaching, is the A horizon. Below is the B horizon consisting of reprecipitated material from above and less altered residues. The C horizon is the lowest zone and consists of partially altered parent material extending downward to the fresh parent material. Portions of the profile may be missing because of erosion or may be very poorly developed.

USDA Texture. The USDA texture is based on the relative amounts of sand, silt, and clay in a soil, giving rise to textural classes such as sand, sandy loam, loam, clay loam, and clay. (See USDA Handbook No. 18, Soil Survey Manual.)

Unified Soil Classification. The Unified Soil Classification System is based on identification of soils according to their grain size distribution and plasticity, and provides a basis for estimation of their performance as engineering construction material. (Corps of Engineers, U. S. Army, Technical Memorandum No. 3-357, Vol. 1, March 1953.) In this system, soil material is divided into 15 classes: 8 classes are for coarse-grained material (GW, GP, GM, GC, SW, SP, SM, SC), 6 for fine-grained (ML, CL, OL, MH, CH, OH), and 1 for organic material (Pt).

Percent of Material Passing Sieve. The measured or estimated percentages of material passing the numbers 4, 10, and 200 sieves describes the soil's grain size distribution and is

given for each major horizon. Soils with less than 50% passing the No. 200 sieve are basically coarse-grained soils consisting of gravel (coarser than No. 4) and/or sand (No. 4 to No. 200). Soils with more than 50% passing the No. 200 sieve are fine-grained, and may be classified as either clays or silts, depending on the plasticity characteristics. Values are rounded off to the nearest 5%. A range is listed because of the variability for a given soil.

Permeability. Values listed are estimates of the range in rate of downward movement of water in the major soil layers when saturated, but allowed to drain freely. The estimates are based on soil texture, soil structure, available data on permeability, infiltration tests, and drainage observations of water movement through soils. In most cases, particularly with soil horizons that are high in clay or organic matter, permeability rates under unsaturated conditions are considerably higher than the values given here. With a given soil type, percolation through the surface layer varies according to land use and management as well as with initial moisture content.

Available Water Capacity. The available water capacity is given in inches per inch of soil for the major horizons. These estimates are for cultivated soils with moderate structure and organic matter content, and average bulk densities. Available water capacity of the soil in inches is the difference between field capacity (1/3 atmosphere) and the wilting percentage (15 atmospheres) times bulk density times the thickness in inches of the soil. The water retention by soil is related to the particle size and to the arrangement and size of soil pores. Fine textured soils tend to have higher water retention due to small pores than do sandy soils with large pores. Estimates of the available water capacity for soils with normally high water tables may appear meaningless until one considers the possibility of artificial drainage or the natural lowering of the water table during dry seasons or late summer or fall. Soils of the same series vary from place to place. Therefore, values can deviate considerably from those listed.

Soil Reaction. Soil reaction or the intensity of soil acidity or alkalinity is expressed in pH--the logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7 is neutral, lower values indicate acidity, and higher values show alkalinity.

Shrink-Swell Potential. Indicates the volume change to be expected of the soil material with changes in moisture content.

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Amasa	0-5	very Fine, sandy loam	SM	100	90-100	75-90	0.8-2.5	0.14	4.5-6.0	low
	5-26	very Fine, sandy loam	SM	100	90-100	75-90	0.8-2.5	0.14	4.5-6.0	low
	26-40	med-coarse sand & gravel	SP-GP	30-60	20-60	0-5	.710	0.02	7.5-8.0	low
Angelica	0-4	muck-loam	ML-CL	100	100	60-70	0.8-2.5	0.20	6.0-7.0	low
	4-15	loam or sandy clay loam	CL	100	95-100	65-80	0.8-2.5	0.18	6.0-7.0	low to moderat
	15-48	loam or silt loam	ML-CL	80-95	75-90	60-80	0.2-0.8	0.16	7.5-8.0	low
Baraga	0-5	muck-silt loam	ML-CL	95-100	90-100	55-70	2.5-5.0	0.18	5.0-6.0	low
	5-33	silt loam	CL	95-100	90-100	25-55	0.8-2.5	0.12	5.5-6.0	low
	33-45	loam	CL	80-95	75-95	20-45	0.2-2.5	0.10	6.0-6.5	low
Bohemian	0-9	silt loam	ML	100	100	70-95	0.8-2.5	0.16	5.0-6.5	low
	9-33	loam, silt loam or light silty clay loam	ML or CL	100	100	70-95	0.2-2.5	0.18	6.0-7.0	low
	33-66	stratified silts + v.Fn. sands	layers of ML & SM	100	95-100	55-70	0.2-2.5	0.16	7.5-8.0 calcareous	low
Carbondale	0-51	muck over peat	Pt	—	—	—	5-10	0.50	5.5-7.0	variable
Cathro	0-50	muck over peat	Pt	—	—	—	5-10	0.30	4.5-6.5	variable

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Champion	0-3	Fn. sandy loam	SM	95-100	90-100	25-45	0.8-2.5	0.12	4.5-5.5	low
	3-36	Fn. sandy loam, silt loam, loam	SM or ML	90-100	85-95	30-60	0.8-2.5	0.16	4.5-5.5	low
	36-60	loamy sand	SM	85-95	80-90	15-35	2.5-5.0	0.08	5.0-5.5	low
Charlevoix	0-10	sandy loam	SM	95-100	90-100	25-45	2.5-6.3	0.12	6.6-7.3	low
	10-30	sandy loam to sandy clay loam	SM-CL	95-100	90-100	40-60	0.8-2.5	0.15	6.6-7.3	low
	30-60	sandy loam	SM	85-95	85-95	20-45	0.8-2.5	0.12	7.5-8.0 calcareous	low
Ensley	0-5	sandy loam	SM	95-100	90-100	25-45	2.5-5.0	0.14	6.0-7.0	low
	5-18	loam to sandy clay loam	CL or SC	95-100	90-100	40-60	0.8-2.5	0.14	6.0-7.0	low
	18-40	sandy loam	SM	85-95	85-95	20-45	0.8-2.5	0.10	7.5-8.0 calcareous	low
Gogebric	0-5	sandy loam	SM	95-100	90-100	30-45	2.5-5.0	0.12	4.5-6.0	low
	5-56	sandy loam	SM	95-100	90-100	25-45	0.8-2.5	0.08	5.0-6.0	low
	56-66	sandy loam	SM	80-95	75-95	25-35	0.8-2.5	0.08	5.0-6.5	low
Goodman	0-5	loam or silt loam	ML or ML-CL	95-100	90-100	55-70	2.5-5.0	0.18	5.5-6.0	low
	5-36	sandy loam or light loam	SC or SM	95-100	90-100	35-60	0.8-2.5	0.14	5.5-6.0	low
	36-50	sandy loam	SM	80-95	75-95	20-45	0.8-2.5	0.10	6.0-6.5	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in/hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Grayling	0-23	loamy sand or sand	SP-SM or SM	100	95-100	5-20	5-10	0.08	5.0-6.5	low
	23-60	sand	SP or SP-SM	100	95-100	0-10	> 10	0.04	5.0-6.5	low
Greenwood	0-51	muck over peat	Pt	—	—	—	5-10	0.50	3.0-5.0	variable
Iron River	0-5	loam or silt loam	ML or ML-CL	95-100	90-100	55-70	2.5-5.0	0.18	5.0-6.0	low
	5-34	sandy loam or light loam	SC or SM	95-100	90-100	35-60	0.8-2.5	0.14	5.5-6.0	low
	34-50	sandy loam	SM	80-95	75-95	20-45	0.8-2.5	0.10	6.0-6.5	low
Kalkaska	0-38	loamy sand or sand	SP-SM or SM	100	95-100	5-20	5-10	0.10	5.0-6.0	low
	38-75	sand	SP	100	95-100	0-5	> 10	0.04	6.0-7.5	low
Karlin	0-23	loamy sand or sandy loam	SM	95-100	95-100	20-35	2.5-5.0	0.12	5.5-6.5	low
	23-60	sand	SP-SM or SM	80-100	75-100	0-10	5-10	0.02	5.5-6.5	low
Keweenaw	0-8	loamy sand	SM	100	100	15-30	2.5-5.0	0.10	4.5-5.5	low
	8-39	loamy sand	SM	100	95-100	20-35	2.5-5.0	0.12	5.0-6.0	low
	39-60	loamy sand	SM	90-100	85-95	15-30	5-10	0.08	5.0-6.0	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No 4	No. 10	No. 200				
Kiva	0-6	sandy loam	SM	90-95	85-95	15-35	0.8-2.5	0.12	6.0-7.0	low
	6-24	sandy loam or loam	SM or ML-CL	85-95	75-95	25-55	0.8-2.5	0.14	6.5-7.5	low
	24-60	stratified gravel, sand & loamy sand	SP or SP-SM	70-90	60-80	0-10	>10	0.03	7.5-8.0	low
Longrie	0-7	sandy loam	SM	90-100	85-95	15-35	0.8-2.5	0.14	6.0-6.5	low
	7-29	sandy loam or loam	SM or ML	90-100	85-95	30-60	0.8-2.5	0.16	6.0-7.5	low
	29	limestone	bedrock	—	—	—	—	—	—	—
Mancelona	0-10	loamy sand or sand	SM or SP-SM	95-100	95-100	10-30	2.5-5.0	0.10	5.5-6.5	low
	10-36	loamy sand	SP-SM	95-100	90-100	30-45	0.8-2.5	0.1 - 0.14	5.5-6.5	low
	36-60	stratified sand & gravel	SP-SM or SP	55-80	50-70	0-10	5-10	0.02	7.5-8.0 calcareous	low
Michigamme	0-4	Fn. sandy loam	SM	90-100	85-95	15-35	0.8-2.5	0.14	6.0-6.5	low
	4-23	Fn. sandy loam	SM	90-100	85-95	30-60	0.8-2.5	0.16	6.0-7.5	low
	23-40	granite	bedrock	—	—	—	—	—	—	—
Munising	0-9	sandy loam	SM	95-100	90-100	25-45	0.8-2.5	0.12	5.0-6.0	low
	9-48	sandy loam or sandy clay loam	SC or SM	95-100	90-100	25-45	0.8-2.5	0.10	5.0-6.0	low
	48-82	Sandy loam	SM	80-95	75-95	20-35	0.8-2.5	0.10	5.0-6.0	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Newaygo	0-7	sandy loam	SM	90-100	85-95	20-35	0.8-2.5	0.12	5.5-6.5	low
	7-34	sandy loam, sandy clay loam or light clay loam	SM or SC	80-90	70-85	30-55	0.8-2.5	0.14	6.0-7.0	low to moderate
	34-60	stratified sand & gravel	GP or SP	30-60	20-60	0-5	> 10	0.02	7.5-8.0 calcareous	low
Onaway	0-3	Fn. sandy loam	SM	100	95-100	60-70	0.8-2.5	0.16	6.0-6.5	low
	3-21	sandy loam to clay loam	SM-CL	95-100	95-100	65-80	0.8-2.5	0.18	6.0-7.0	moderate to low
	21-40	silt loam	ML	90-95	85-95	55-70	0.2-0.8	0.16	7.5-8.0 calcareous	low
Onota	0-7	sandy loam	SM	95-100	90-100	25-45	2.5-5.0	0.14	4.5-6.0	low
	7-32	loamy sand	SM	95-100	90-100	20-35	2.5-5.0	0.14	4.5-6.0	low
	32-36+	sandstone	bedrock	—	—	—	—	—	—	—
Ontonagon	0-10	loam or silt loam	ML or ML-CL	100	100	70-90	0.8-2.5	0.16	6.0-7.0	low
	10-36	silty clay or clay	CH	100	100	75-95	0.05-0.2	0.16	5.0-6.5	high
	36-50	silty clay or clay	CH	100	95-100	75-95	< 0.2	0.16	7.5-8.0 calcareous	high
Pence	0-2	sandy loam	SM	90-100	80-100	20-35	2.5-5.0	0.10	5.0-6.0	low
	2-20	loam to sandy loam	SM or CL	85-95	80-95	30-65	0.8-2.5	0.16	5.0-6.0	low
	20-30	stratified gravel & sand	SP	60-90	55-80	0-5	> 10	0.02	5.5-6.0	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-swell Potential
		USDA Texture	Unified	No 4	No. 10	No. 200				
Pleine	0-11	loamy sand	SM	95-100	90-100	15-25	2.5-5.0	0.12	5.5-6.5	low
	11-19	sandy sand	SM	95-100	90-100	20-35	0.8-2.5	0.10	5.5-6.5	low
	19-30	sandy sand	SM	90-100	85-95	20-45	0.8-2.5	0.10	5.5-6.5	low
Rifle	0-51	muck over peat	Pt	—	—	—	5-10	0.50	4.5-6.5	variable
Roscommon	0-4	loamy sand	SP-SM	100	100	5-10	5-10	0.08	5.5-6.5	low
	4-20	sand	SP	100	95-100	0-5	>10	0.04	7.0-7.5	low
	20-45	sand	SP	85-100	80-95	0-5	>10	0.02	7.5-8.0	low
Rousseau	0-8	loamy Fn. sand	SM	100	100	15-30	5-10	0.10	5.0-6.0	low
	8-25	loamy Fn. sand	SP-SM or SM	100	100	5-25	5-10	0.08	5.5-6.5	low
	25-60	stratified Fn. sand, v.Fn. sand & loamy Fn. sand	layers of SP & SM	100	100	5-25	5-10	0.09	5.5-6.5	low
Rubicon	0-6	loamy sand or sand	SP-SM or SM	100	95-100	5-20	5-10	0.10	5.0-6.0	low
	6-36	sand	SP	100	95-100	0-5	>10	0.04	5.0-6.5	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-Swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Shelldrake	0-7	sand	SP-SM or SM	100	95-100	0-10	5-10	0.10	5.0-6.0	low
	7-28	sand	SP	100	95-100	0-5	>10	0.04	5.0-6.0	low
Skanee	0-5	sandy loam	SM	95-100	90-100	25-45	2.5-5.0	0.12	4.5-6.0	low
	5-33	sandy loam & sandy clay loam	SM or SC	95-100	90-100	25-45	0.8-2.5	0.10	5.0-6.0	low
	33-60	sandy loam	SM	80-95	75-95	20-35	0.8-2.5	0.10	5.0-6.0	low
Stambaugh	0-5	silt loam	ML	100	100	70-90	0.8-2.5	0.20	5.0-5.5	low
	5-34	silt loam	ML	100	100	70-90	0.8-2.5	0.20	5.0-5.5	low
	34-60	stratified sand & gravel	SP or GP	40-60	35-65	0-5	>10	0.02	5.5-6.0	low
Tacoosh	0-51	muck over peat	Pt	—	—	—	5-10	0.50	4.5-6.5	variable
Tawas	0-31	muck or peat	Pt	—	—	—	5-10	0.50	5.5-6.5	variable
	31-60	sand	SP-SM or SP	100	95-100	0-10	>10	0.04	6.0-7.0	low
Trenary	0-6	sandy loam	SM	95-100	90-100	20-35	2.5-5.0	0.12	6.0-7.0	low
	6-37	loam, sandy clay loam or clay loam	ML-CL or SC	95-100	90-100	45-70	0.8-2.5	0.16	6.0-7.0	low
	37-60	sandy loam or loam	SM or ML-CL	85-95	80-95	30-50	0.8-2.5	0.14	7.5-8.0 calcareous	low

Estimated Soil Engineering Properties

Soil Series	Major Soil Horizons	Classification		% of Material Passing Sieve			Permeability in./hr.	Available Water Capacity in./in.	Soil Reaction	Shrink-swell Potential
		USDA Texture	Unified	No. 4	No. 10	No. 200				
Watton	0-13	silt loam	ML	95-100	95-100	65-80	0.8-2.5	0.18	6.0-7.0	low
	13-54	clay loam or light clay	CL or CH	95-100	95-100	70-85	0.2-0.8	0.16	6.0-7.0	moderate
	54-70	silty clay loam or clay loam	CL	90-95	85-90	70-90	0.2-0.8	0.16	7.5-8.0 calcareous	moderate
Witbeck	0-12	loamy sand	SM	95-100	90-100	15-25	2.5-5.0	0.12	5.5-6.5	low
	12-19	sandy loam	SM	95-100	90-100	20-35	0.8-2.5	0.10	5.5-6.5	low
	19-60	sandy loam	SM	85-95	75-95	20-45	0.8-2.5	0.10	5.5-6.5	low

APPENDIX C

SOIL SUITABILITY AS RESOURCE MATERIAL

AND FEATURES AFFECTING RELATED USES

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features AFfecting Related Uses		
	Topsoil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
	Three degrees of suitability are used, as follows: Good -- Soils have properties that are favorable or perform very well for the kind of use being rated. Fair -- Soils have properties that are moderately favorable or perform satisfactorily for the rated use, but special planning and management are needed. Poor -- Soils have properties that, in their natural state, make them unfavorable or unsatisfactory for the rated use. Major kind of limitations affecting use is shown by the following abbreviations: (b) - bedrock, (c) - coarse texture, (d) - droughtiness, (f) - frost hazard, (p) - hardpan restricting permeability, (o) - organic soil, (s) - slope, (st) - stoniness, (t) - fine soil texture, (w) - wetness.						

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features Affecting Related Uses		
	Topsoil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Amasa	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	Fair (d)	Fair (d)	Fair (d)
Angelica	Good-6"-8", loamy, med to hi content of organic matter, high water table	not suitable	not suitable	Fair to poor-low to mod vol. change Fair to poor bearing capacity, Fair workability when wet, high water table	poor (w)	Fair (w,F)	Fair (w)
Baraga	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	good	good -- poor (s,st)	good -- Fair (s)
Bohemian	Fair-6"-8", loamy, low organic content	poor-highly variable, stratified material thin layers of Fn. & v. Fn. sands	not suitable	poor-low volume change, poor bearing capacity & material flows when wet.	good	Fair (s) -- poor (s)	good -- Fair (s)
Carbondale	poor-erosive & oxides readily, Fair to good if mixed with mineral material; high water table.	not suitable	not suitable	not suitable-unstable, highly compressible	poor (w,o)	poor (w,F,o)	poor (w,o)
Cathro	poor-erosive & oxidizes readily	not suitable	not suitable	not suitable in upper layers, Fair to poor in loamy material	poor (w)	Fair (w,F)	Fair (w)
Champion	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	good	Fair (s) -- poor (s)	good -- Fair (s)
Charlevoix	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair-low volume change, difficult to work & compact when wet	Fair (w)	Fair (w)	good -- Fair (w)

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features Affecting Related Uses		
	Topsoil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Ensley	good-6"-8" high water table, med to hi content of organic matter	not suitable	not suitable	Fair to good-low volume change, Fair to good bearing capacity, stones & cobble present	poor (w)	Fair (w,F)	Fair (w)
Gogebric	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	good	good--poor(s)	good--Fair(s)
Goodman	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	good	good--Fair(s)	good
Grayling 40	very poor-thin, sandy, low organic content	good-sandy material to a depth of 60"+	not suitable	Fair to good-low volume change, Fair to good bearing capacity	poor (d)	poor (d)	poor (d)
Greenwood	poor-erosive & oxidizes readily; Fair to good if mixed with mineral material	not suitable	not suitable	not suitable-unstable, highly compressible	poor (w,o)	poor (w,F,o)	poor (w,o)
Iron River	Fair-thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good-low volume change, good to Fair bearing capacity	good	good--poor (s,st)	good--Fair (s)
Kalkaska	very poor-thin, 6"-8", sandy, low organic content	good-sandy material to a depth of 60"+	not suitable	Fair to good-low volume change, Fair to good bearing capacity	Fair (d)	poor(d)	poor (d)
Karlin	poor-drouthy, low organic content, gravel & cobble on surface in many areas	good-sands with some Fines & gravel below 15"-42"	poor-7 50% sand with some Fines, below 15"-42"	good-low volume change, sandy material provides good subgrade material	good	good--Fair (s,d)	good--Fair(d)
Keweenaw	good-6"-8" high water content, med content of organic matter	not suitable	not suitable	Fair to good-low volume change, Fair to good bearing capacity	good	Fair(d)	Fair (d)

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features Affecting Related Uses		
	Top-soil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Kiva	poor-drouthy, low organic content, gravel & cobble on surface in many areas	good- sands with some Fines & gravel	Fair- >50% sand with some Fines	good- low volume change, sandy & gravelly material provides good subgrade material	Fair (d)	Fair(d)-- poor(d,s)	Fair(d)
Longrie	very poor, thin, low content of organic matter	not suitable	not suitable	Fair to good at 18"-42"; low volume change, good to Fair bearing capacity	Fair(b)	Fair(b)	good
Mancelona	poor-drouthy, low organic content, gravel & cobble on surface in many areas	good-sands with some Fines & gravel	Fair- >50% sand with some Fines	good- low volume change, sandy & gravelly material provides good subgrade material	Fair (d)	Fair(d,s)	Fair (d)
Michigamme	very poor-thin, low content of organic matter	not suitable	not suitable	Fair to good at 18"-42"; low volume change, good bearing capacity	Fair(b)-- poor (b,s)	poor (b,s)	Fair(s)-- poor(s)
Munising	Fair- thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good- low volume change, good to Fair bearing capacity	good	good-- Fair(s)	good
Newaygo	Fair- drouthy, low content of organic matter, gravel & cobble on surface in many areas	good- sands with some Fines & gravel	good >40% gravel	good- low volume change, sandy & gravelly material provides good subgrade & subbase material	good	good	good
Onaway	Fair- thin gravel & cobble on surface in some areas	not suitable	not suitable	poor to Fair- low to moderate volume change	good	good-- Fair(s)	good
Onota	very poor-thin, low content of organic matter	not suitable	not suitable	Fair to good in upper 20"-40", low volume change, good to Fair support capacity	Fair(b)	Fair(b)	good-- Fair(b)

Soil Suitability as Resource Material and Features AFFecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features AFFecting Related Uses		
	Topsoil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Ontonagon	Fair- thin 6"-9"; low organic content	not suitable	not suitable	poor- poor shear strength, workability, and bearing capacity; high volume change	good	Fair (t)	good
Pence	poor- 8"-10"; drouthy, low content OF organic matter	good- mixture OF sand & gravel	good- mixture OF sand & gravel	good- low volume change, sandy & gravelly material provides good subgrade material	Fair (d)	Fair (d)	Fair (d)
Pleine	good- 9"-12" high water table	not suitable	not suitable	Fair to good- low volume change, good to Fair bearing capacity	poor (w)	poor (w,F,st)	Fair (w,st)
RiFle	poor- erosive & oxidizes readily. Fair to good if mixed with mineral material high water table	not suitable	not suitable	not suitable- unstable, highly compressible	poor (w,o)	poor (w,o,F)	poor (w,o)
Roscommon	poor- sandy, subject to wind erosion, high water table	good- sandy material	not suitable	Fair to good- low volume change, Fair to good capacity to support loads	poor (w)	poor (w,F,c)	poor (w)
Rousseau	very poor- thin 6"-8", sandy, low organic content, drouthy	good- sandy material to a depth OF 60"+	not suitable	Fair to good- low volume change, Fair to good bearing capacity	Fair (d)	Fair (d)	Fair (d)
Rubicon	very poor- thin, sandy, low organic content	not suitable	not suitable	Fair to good- low volume change, Fair to good bearing capacity	Fair (d)	Fair (d)	Fair (d)

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features Affecting Related Uses		
	Top-soil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Shelldrake	very poor, thin, 6"-8" sandy, low organic content, drouthy	good- sandy material 60"+	not suitable	Fair to good - low volume change, Fair to good bearing capacity	Fair (d)	poor (d)	poor (d)
Skanee	Fair - thin, loamy. cobble & stone on surface in some areas	not suitable	not suitable	Fair to good - low volume change, good to Fair bearing capacity	Fair (w)	Fair (w)	good - Fair (w)
Stambaugh	Fair to good - thin, low organic content	good - stratified sand & gravel below a depth ranging From 24-42"	good - stratified sand & gravel below a depth	Fair to poor, mod. vol. change, Fair to poor bearing capacity, subject to Frost heave	good	good	good
Tacoosh	poor - erosive soil oxidizes readily - Fair to good if mixed with mineral material	not suitable	not suitable	not suitable in upper organic layers - unstable, highly compressible	poor (w,o)	poor (w,o,F)	poor (w,o)
Tawas	poor - erosive & oxidizes readily; Fair to good if mixed with mineral material	Fair - sandy material at a depth ranging From 18"-42", excess water hinders excavation	not suitable	not suitable - inorganic material unstable, highly compressible - excavation difficult because of wetness	poor (w,o)	poor (w,F,o)	poor (w,o)
Trenary	Fair - thin, loamy cobble & stone on surface in some areas	not suitable	not suitable	Fair to good - low volume change, good to Fair bearing capacity	good	good -- Fair (s)	good

Soil Suitability as Resource Material and Features Affecting Related Uses

Soil Series	Suitability as Resource Material				Suitability and Features Affecting Related Uses		
	Topsoil	Sand	Gravel	RoadFill	Forestry	Cropland	Pasture
Watton	Fair- 7"-9", loamy low content of organic matter, Few gravel & cobble on surface	not suitable	not suitable	poor to Fair- moderate volume change, Fair to poor bearing capacity	good	good -- Fair (s)	good
Witbeck	good- 9"-12", high water table	not suitable	not suitable	Fair to good - low volume change, Fair to good bearing capacity	poor(w)	poor (w,st)	poor (w,st)

APPENDIX D

DEGREE AND KIND OF LIMITATION FOR SELECTED USES

Degree and Kind of Limitation For Selected Uses

Soil Series	Residential Dwellings		Recreational				Septic Tank Absorption Field
	with basement	without basement	Playgrounds	Camp Areas	Picnic Areas	Paths and Trails	
	Three degrees of limitations are used, as follows: Slight - relatively free of limitations or limitations are easily overcome. Moderate - limitations need to be recognized but can be overcome with good management and careful design. Severe - limitations are severe enough to make use questionable; usage may be unsound or impractical. Major kind of limitation affecting use is shown by the following abbreviations: (b) bedrock, (c) coarse texture, (d) droughtiness, (f) frost hazard, (p) hardpan restricting permeability, (o) organic soil, (rp) rapid permeability of the subsoil or substratum, (s) slope, (st) stoniness, (t) fine soil texture, (w) wetness.						
96 Amasa	slight	slight	slight-moderate(s)	slight	slight	slight	slight (rp)
Angelica	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w,t)
Baraga	slight-severe(s)	slight-severe (s)	moderate (s,t)	moderate (s,t)	slight-severe(s)	slight-moderate (s)	severe (p,s)
Bohemian	slight-severe(s)	slight-severe(s)	moderate(s)-severe(s)	slight-severe(s)	slight-severe(s)	slight-moderate(s)	slight-severe (s,t)
Carbondale	severe(w,o)	severe (w,d)	severe(w,o)	severe(w,d)	severe(w,d)	severe(w,d)	severe (w,o)
Cathro	severe(w,o)	severe(w,d)	severe (w,o)	severe(w,o)	severe(w,d)	severe (w,d)	severe (w,o)
Champion	slight-severe(s)	slight-severe(s)	moderate(s)-severe(s)	slight-severe(s)	slight-severe(s)	slight-moderate(s)	slight-moderate (p,s)
Charlevoix	severe (w)	moderate (w)	severe (w)	severe (w)	moderate (w)	moderate (w)	severe (w)

Degree and Kind of Limitation For Selected Uses

Soil Series	Residential Dwellings		Recreational				Septic Tank Absorption Field
	with basement	without basement	Playgrounds	Camp Areas	Picnic Areas	Paths and Trails	
Ensley	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)
Gogebric	slight-moderate (s)	slight-moderate (s)	moderate (s)-severe (s,st)	slight-moderate (s,st)	slight-moderate (s)	slight	moderate (p)-severe (p,s)
Goodman	slight-moderate (s)	slight-moderate (s)	moderate (s)-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	moderate (p)
Grayling	slight	slight	moderate (c)-severe (s,c)	moderate (c)	moderate (c)	moderate (c)	slight (rp)
Greenwood	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)
Iron River	slight-severe (s)	slight-severe (s)	moderate (s)-severe (s,st)	slight-severe (s,st)	slight-severe (s,st)	slight-moderate (s)	moderate (p)-severe (p,s)
Kalkaska	slight-severe (s)	slight-severe (s)	moderate (c,s)-severe (c,s)	moderate (c)-severe (c,s)	moderate (c)-severe (c,s)	moderate (c)-severe (c,s)	slight-severe (rp)
Karlin	slight-severe (s)	slight-severe (s)	moderate (s)-severe (s)	slight-severe (s)	slight-severe (s)	slight-moderate (s)	slight-severe (s,rp)
Keweenaw	slight-severe (s)	slight-severe (s)	slight-severe (s)	slight-severe (s)	slight-severe (s)	slight-moderate (s)	slight-moderate (s)
Kiva	slight-moderate (s)	slight-moderate (s)	moderate (s)-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	slight-moderate (s)
Longrie	severe (b)	moderate (b)	moderate (s)	slight	slight	slight	severe (b)
Mancelona	slight-moderate (s)	slight-moderate (s)	slight-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	slight-moderate (s)

Degree and Kind of Limitation For Selected Uses

Soil Series	Residential Dwellings		Recreational				Septic Tank Absorption Field
	with basement	without basement	Playgrounds	Camp Areas	Picnic Areas	Paths and Trails	
Michigamme	severe (b,s)	moderate-severe (b,s)	severe (s,b)	severe (s,b)	severe (s)	slight-moderate (s)	severe (b,s)
Munising	slight-severe (s)	slight-severe (s)	moderate (s)-severe (s)	slight-severe (s)	slight-severe (s)	slight-moderate (s)	severe (p,s)
Newaygo	slight-moderate (s)	slight-moderate (s)	moderate-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	slight (rp) moderate (s)
Onaway	slight-moderate (s)	slight-moderate (s)	moderate (s)-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	moderate (t,s)
Onota	severe (b)	moderate (b)	slight-moderate (b,s)	slight	slight	slight	severe (b)
Ontonagon	severe (t)	severe (t)	moderate (t,s)-severe (t,s)	moderate (t,s)	slight-moderate (t,s)	slight-moderate (t,s)	severe (t)
Pence	slight-moderate (s)	slight-moderate (s)	slight-severe (s)	slight-moderate (s)	slight-moderate (s)	slight	slight (rp)-moderate (s)
Pleine	severe (w)	severe (w)	severe (w,st)	severe (w,st)	severe (w,st)	severe (w)	severe (w,st)
Rifle	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)
Roscommon	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)
Rousseau	slight-moderate (s)	slight-moderate (s)	moderate (c)-severe (c,s)	moderate (c,s)	moderate (c,s)	moderate (c)	slight (rp)-moderate (s)

Degree and Kind of Limitation For Selected Uses

Soil Series	Residential Dwellings		Recreational				Septic Tank Absorption Field
	with basement	without basement	Playgrounds	Camp Areas	Picnic Areas	Paths and Trails	
Rubicon	slight-moderate (s)	slight-moderate (s)	moderate (c,s)-severe (c,s)	moderate (c,s)	moderate (c,s)	moderate (c)	slight (rp)-moderate (s)
Shelldrake	slight	slight	moderate (s,c)-severe	moderate (c)	moderate (c)	moderate (c)	slight (rp)
Skanee	severe (w)	moderate (w)	moderate (w)	moderate (w)	moderate (w)	moderate (w)	severe (p,w)
Stambaugh	slight	slight	slight-moderate (s)	slight	slight	slight	slight (rp)
Tacoosh	severe (w,o)	severe (w,o)	severe (w,p)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)
Tawas	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)	severe (w,o)
Trenary	slight-moderate (s)	slight-moderate (s)	moderate (s)-severe (s)	slight-moderate (s)	slight-moderate	slight	slight
Watton	moderate (t)	moderate (t)	moderate (s,t)	moderate (s,t)	slight	slight	severe (t)
Witbeck	severe (w)	severe (w)	severe (w,st)	severe (w,st)	severe (w,st)	severe (w)	severe (w)
Organic Soils	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)
Rock land	severe (b,s)	severe (b,s)	severe (b,s)	severe (b,s)	severe (b,s)	severe (b,s)	severe (b,s)
Alluvial land	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)	severe (w)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